C. A. Lundquist Chief, Structures Res. Div.

977

RESTRICTED

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE

No. 974

BEARING STRENGTHS OF 75S-T ALUMINUM-ALLOY SHEET AND EXTRUDED ANGLE

By C. Wescoat and R. L. Moore
Aluminum Company of America

Washington
February 1945

RESTRICTED

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE NO. 974

BEARING STRENGTHS OF 75S-T ALUMINUM-ALLOY SHEET AND EXTRUDED ANGLE

By C. Wescoat and R. L. Moore

INTRODUCTION AND OBJECT

Several reports have been issued covering the bearing properties of the wrought aluminum alloys commonly used in aircraft construction (reference 1). The development of the new high-strength alloy 75S-T has made bearing tests of this material desirable.

The object of this investigation was to determine the bearing yield and ultimate strengths of 75S-T alloy in the form of sheet, in both with- and across-grain directions, and extruded angle in the longitudinal direction. Ratios of bearing to tensile properties were also determined.

It should be emphasized that the sheet used in this investigation was nonclad sheet. Previous investigations have indicated, however, that ratios of bearing properties to tensile properties established for nonclad sheet are equally applicable to alclad sheet.

PROCEDURE AND MATERIAL

The procedure followed in these bearing strength determinations was the same as described in the earlier reports for the single-thickness type specimens (reference 1). A photograph of the test setup is shown in figure 1. The sheet specimens were 2-inch-wide strips of 0.064-inch sheet, loaded in bearing on a 1/4-inch diameter steel pin. The angle specimens were machined from one leg of a 1/4-inch thick extruded angle (Die No. 28265) and were 2 inches wide by 1/4 inch thick, loaded on a 1/2-inch diameter steel pin.

These specimen proportions were found to be satisfactory in previous tests of this type. Measurements of hole elongation were made with a filar micrometer microscope. Tests were made in triplicate for edge distances of 1.5, 2, and 4 times the pin diameter.

The tensile properties of the sheet and extruded angle are shown in table I. These values are within the range considered typical for 75S-T alloy in these forms.

RESULTS AND DISCUSSION

The individual bearing test results are shown in table II. The bearing yield strength values were obtained from the bearing stress-hole elongation curves shown in figures 2 to 4, using an offset from the initial straight line portion of the curves equal to 2 percent of the pin diameter. Indicated also in table II are the types of failures obtained. Failures by shear and tension in the margin above the pin were predominant for edge distances of 1.5 and 2 diameters for both sheet and extruded material. For edge distances of 4 diameters, failures occurred by bearing or crushing the metal above the pin.

Ratios of average bearing to tensile properties are shown in table III. Since the bearing properties for the sheet did not show marked directional characteristics, the percentage differences in ratios of bearing yield to tensile yield strength for the two directions are of about the same magnitude as the differences in tensile yield strengths given in table I. The ratios for the 75S-T sheet are in good agreement with those previously obtained for other high strength aluminum alloys in the plain and alclad forms, as shown in table IV. The ratios for the extruded angle, however, are appreciably lower than obtained for other alloys in the form of thin extrusions. Additional tests are obviously needed to indicate bearing values for thicker 75S-T extrusions.

CONCLUSIONS

The results of this investigation of the bearing properties of 75S-T bare sheet (0.064 in.) and 75S-T extruded angle

(1/4 in. thick) are believed to justify the following conclusions:

1. Since the tensile properties of the materials used were within expected limits for 75S-T, the bearing strength ratios presented may be considered representative for commercial material.

2. As indicated in table II, the bearing properties of 75S-T sheet do not show significant directional characteristics. The differences in ratios of bearing yield to tensile yield strength shown in table III for the with- and cross-grain directions reflect differences in tensile yield strength rather than differences in bearing properties.

3. The ratios of bearing to tensile properties shown in table IV for the 75S-T sheet are in good agreement with the ratios previously reported for other high strength aluminum alloys in both bare and alclad forms. The ratios of the present tests may be considered applicable, therefore, to alclad as well as to bare 75S-T sheet. The ratios for the 75S-T extruded angle are approximately 16 percent less than obtained for the 75S-T sheet. Additional tests of thicker extrusions are needed.

4. The following nominal ratios of bearing to tensile properties are proposed for the material tested.

Material	Edge distance = 1.5 × pin diameter		Edge distance = 2 or more × pin diameter	
	BS/TS	BYS/TYS	BS/TS	BYS/TYS
75S-T sheet (W)	1.5	1.4	1.9	1.6
1/4-in. 75S-T extruded angle	1.3	1.3	1.6	1.4

The above ratios for sheet are applicable to with-grain tensile properties only and are the same as recently proposed for the other high strength aluminum alloys in the form of sheet. The ratios for the extruded angle should be limited to thicknesses of material of approximately 1/4 inch until the bearing strength of other thicknesses can be investigated.

Aluminum Research Laboratories,
Aluminum Company of America,
New Kensington, Pa., June 9, 1944.

REFERENCES

1. Moore, R. L., and Wescoat, C.: Bearing Strengths of Some Wrought-Aluminum Alloys. NACA TN No. 901, 1943.

Moore, R. L., and Wescoat, C.: Bearing Strengths of Bare and Alclad XA75S-T and 24S-T81 Aluminum Alloy Sheet. NACA TN No. 920, 1943.

TABLE I

TENSILE PROPERTIES OF 75S-T SHEET (0.064 IN.) AND EXTRUDED ANGLE (1/4-IN. THICK) USED FOR BEARING TESTS

Material	Specimen Direction*	Ultimate Strength, psi	Yield Strength (0.2% Offset), psi	Elongation in 2 in., per cent
Sheet	With-Grain (W)	80 600	70 500	14.0
Sheet	Across-Grain (X)	80 000	66 400	13.7
Extrusion	Longitudinal (L)	91 600	82 800	10.0

* Standard tension test specimens for sheet metals - Fig. 2 of Standard Methods of Tension Testing of Metallic Materials (E8-42), 1942 Book of A.S.T.M. Standards, Part I, p. 898.

TABLE II

BEARING STRENGTHS OF 75S-T SHEET (0.064 IN.) AND EXTRUDED ANGLE (1/4 IN. THICK)

Material	Test No.	Bearing Strength, psi								
		Edge Distance = 1.5 x Pin Diameter		Type of Failure**	Edge Distance = 2 x Pin Diameter		Type of Failure**	Edge Distance = 4 x Pin Diameter		Type of Failure**
		Ultimate	Yield*		Ultimate	Yield*		Ultimate	Yield*	
Sheet (W)	1	133 300	101 500	S	160 000	117 500	S	184 700	124 000	B
	2	133 900	105 500	S	166 600	117 500	S	178 100	124 000	B
	3	128 800	102 000	S	165 200	117 000	S	181 300	123 500	B
	Avg	132 000	103 000		163 900	117 300		181 400	123 800	
Sheet (X)	1	129 800	101 500	S	167 800	114 000	S	177 000	124 000	B
	2	130 800	103 000	S	157 800	115 500	B	189 300	124 000	B
	3	128 000	102 000	S	166 900	116 500	S	195 900	121 500	B
	Avg	129 500	102 500		164 200	115 300		187 400	123 200	
Extrusion (L)	1	122 600	106 000	S	160 800	123 000	S	179 300	118 000	B
	2	123 800	106 200	S	152 500	112 000	S	169 400	117 000	B
	3	123 500	104 500	S	151 300	114 000	S	174 800	118 000	B
	Avg	123 300	105 500		154 900	119 600		174 500	117 600	

Tests of sheet on 1/4-in. diameter steel pin (D/t = 4). Tests of extruded angle on 1/2-in. diameter steel pin (D/t = 2). All specimens 2 in. wide.

* Stress corresponding to offset of 2 per cent of hole diameter from initial straight line portion of bearing stress - hole elongation curves shown in Figs. 2 to 4 (0.005 in. offset for 1/4-in. pin; 0.010 offset for 1/2-in. pin).

** Type of failure: (B) - Bearing or crushing, (S) - Shear and tension.

TABLE III

RATIOS OF AVERAGE BEARING TO TENSILE STRENGTH FOR 75S-T SHEET (0.064 IN.) AND EXTRUDED ANGLE (1/4 IN. THICK)

Material	Edge Distance = 1.5 x Pin Diameter		2.0 x Pin Diameter		4.0 x Pin Diameter	
	BS/TS	BYS/TYS	BS/TS	BYS/TYS	BS/TS	BYS/TYS
Sheet (W)	1.63	1.46	2.03	1.66	2.25	1.76
Sheet (X)	1.62	1.54	2.05	1.74	2.34	1.86
Extrusion (L)	1.35	1.27	1.69	1.44	1.91	1.42

Bearing tests of sheet on 1/4-in. diameter steel pin (D/t = 4)
Bearing tests of angle on 1/2-in. diameter steel pin (D/t = 2)
All specimens 2 in. wide.

BS = Bearing Strength
BYS = Bearing Yield Strength (Offset = 0.02 x pin diameter)
TS = Tensile Strength
TYS = Tensile Yield Strength (Offset = 0.2 per cent)

TABLE IV

COMPARISON OF RATIOS OF BEARING TO TENSILE STRENGTH FOR VARIOUS WROUGHT ALUMINUM ALLOYS

Alloy	Reference	Edge Distance = 1.5 x Pin Diameter		2.0 x Pin Diameter		4.0 x Pin Diameter	
		BS/TS	BYS/TYS	BS/TS	BYS/TYS	BS/TS	BYS/TYS
			0.064-in. Sheet				
24S-T (W)	12-43-7	1.52	1.41	1.98	1.64	2.37	1.80
Alc.24S-T (W)	12-43-7	1.53	1.37	2.00	1.56	2.35	1.70
24S-RT (W)	12-43-7	1.45	1.40	1.83	1.54	2.32	1.71
XA75S-T (W)	12-43-19	1.72	1.51	2.23	1.71	2.61	1.79
Alc.XA75S-T (W)	12-43-19	1.62	1.42	2.08	1.61	2.35	1.71
24S-T81 (W)	12-43-19	1.45	1.42	1.97	1.59	2.39	1.62
Alc.24S-T81 (W)	12-43-19	1.54	1.46	2.06	1.61	2.48	1.65
75S-T (W)	Present tests	1.63	1.46	2.03	1.66	2.25	1.76
75S-T (X)	Present tests	1.62	1.54	2.05	1.74	2.34	1.86
			Extrusions				
24S-T(.070 in. thick)	12-43-7	1.54	1.42	1.91	1.69	2.45	1.89
24S-T(3-3/4 in. thick)	P.T. 42-65	1.18	1.23	1.54	1.44	2.08	1.60
75S-T (1/4 in. thick)	Present tests	1.35	1.27	1.69	1.44	1.91	1.42

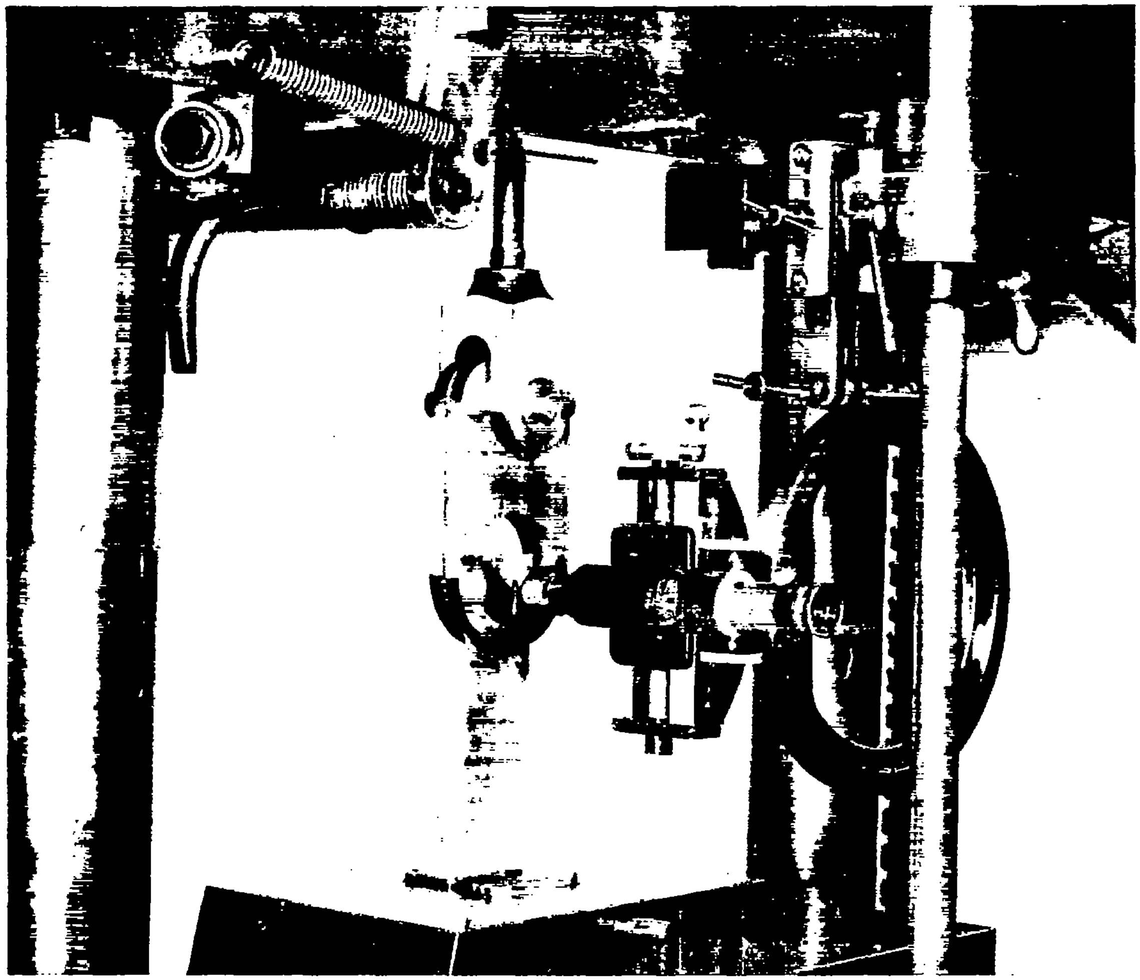

Figure 1.- Arrangement for bearing tests using Filar micrometer microscope for measurements of hole elongation.

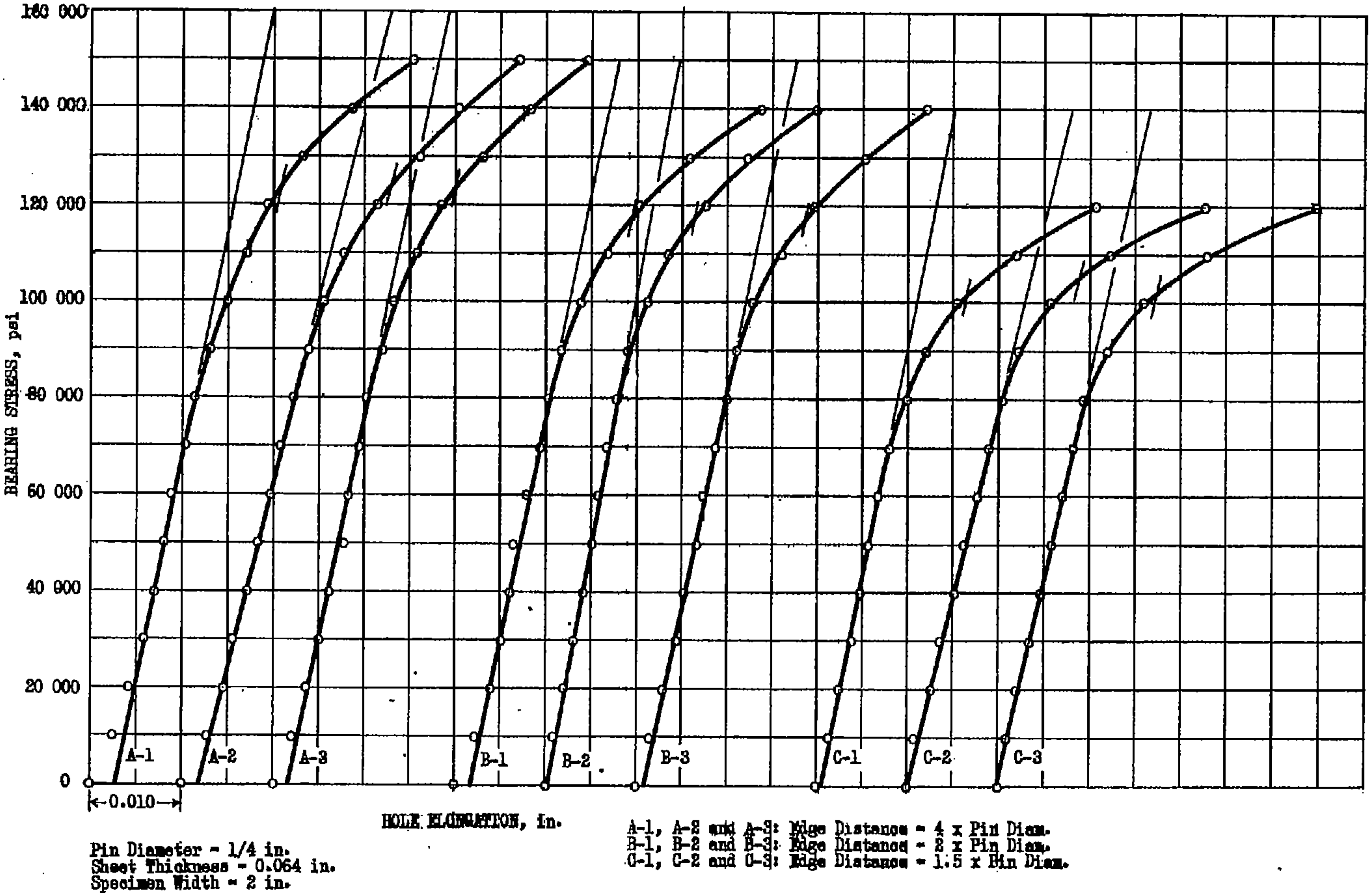

Figure 2.- Bearing stress-hole elongation curves for aluminum alloy sheet, 75S-T (W grain).

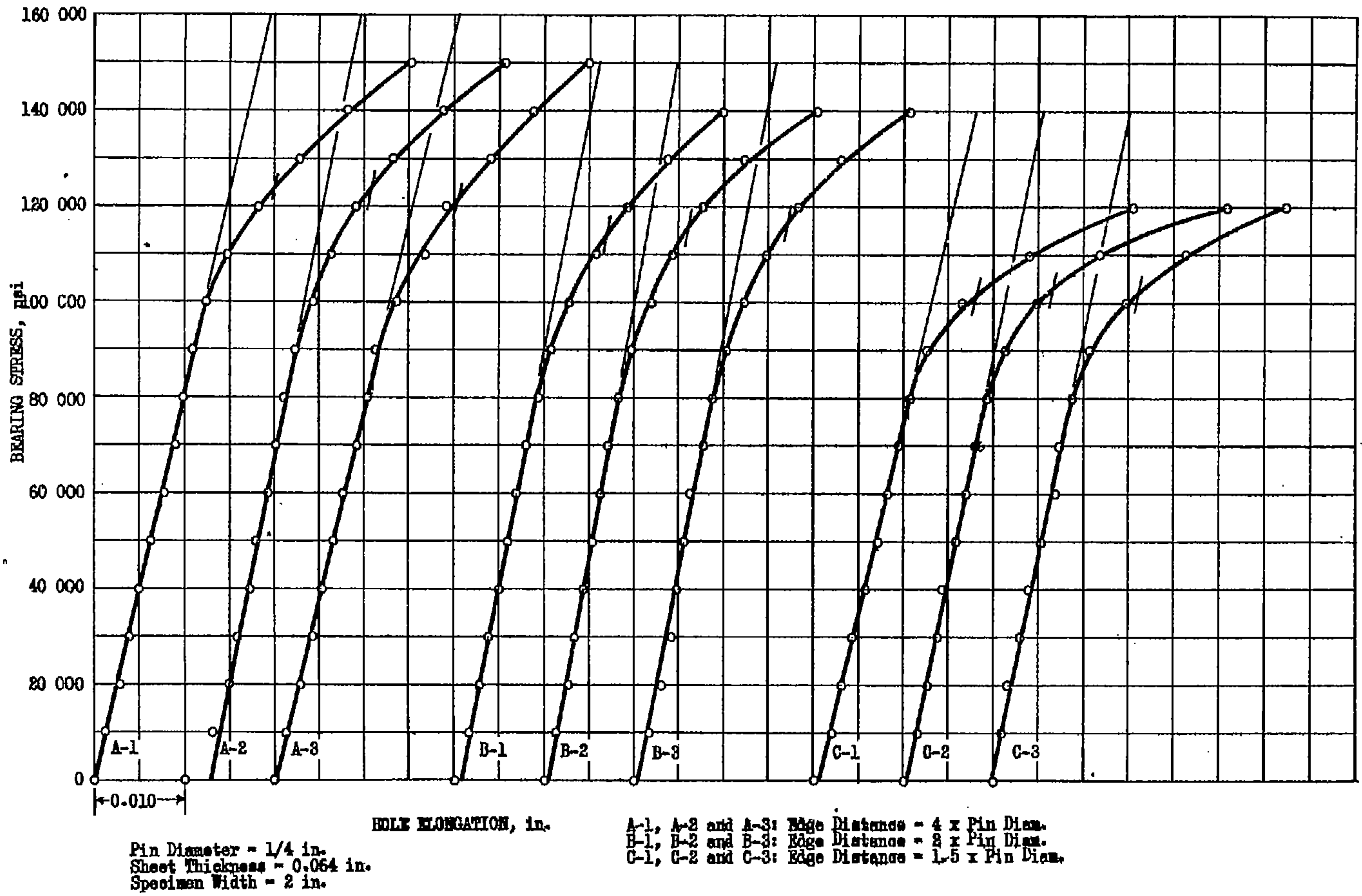

Figure 3.- Bearing stress-hole elongation curves for aluminum alloy sheet, 75S-T (X grain).

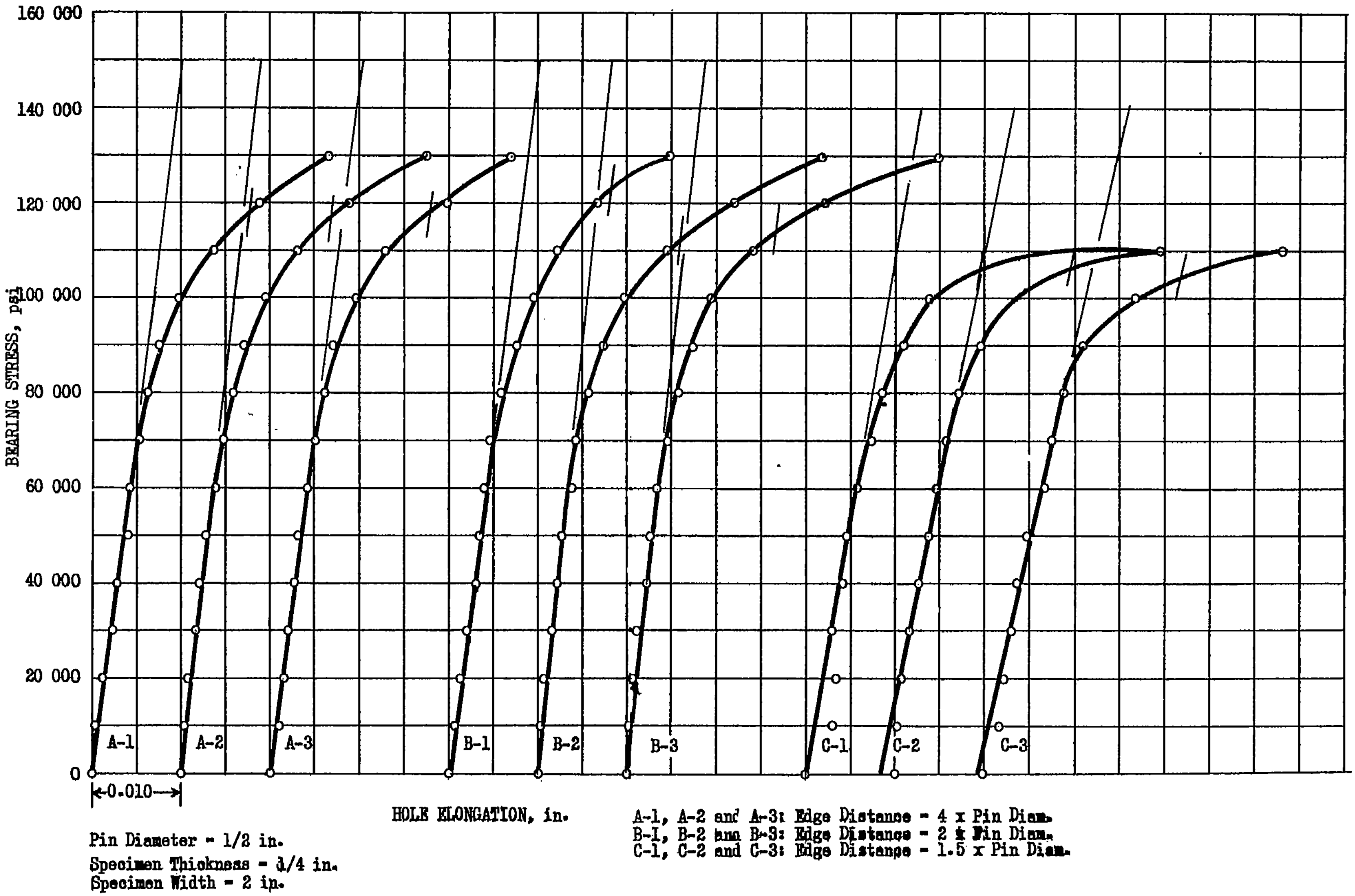

Figure 4.- Bearing stress-hole elongation curves for aluminum alloy extruded angle, 75S-T.